

**Amendments to the Specification:**

Please replace the abstract of the specification with the following rewritten abstract:

--A system for the plasma treatment of parts. The system includes a chamber base sealingly engageable with a reaction chamber to form a treatment chamber and a lifting device operable to lift the reaction chamber from the chamber base. A transfer mechanism is operable to transfer parts along a guide to multiple treatment positions within the treatment chamber when the reaction chamber is disengaged from the chamber base. An electronic control system controls the transfer mechanism for transferring the plurality of parts to the treatment positions. The parts are treated with a plasma produced within the treatment chamber by a plasma-generating device.--

Please replace the first paragraph of the specification with the following rewritten paragraph:

--This application is a continuation of U.S. Application No. 09/012,743, which was filed [[on]] January 23, 1998, now Patent No. 6,245,189, which is a continuation-in-part of U.S. Application No. 09/601,687, which was filed [[on]] February 15, 1996 (abandoned), which is a continuation-in-part of Application No. 567,797, filed December 5, 1995, now Patent No. 5,766,404, which is a continuation-in-part of Application No. 350,320, filed December 5, 1994 (abandoned).--

Please replace the paragraph beginning on page 4, line 3 with the following rewritten paragraph:

-- U.S. Pat. No. 4,889,609 to Cannella discloses an automated dry etching system which is titled "Continuous" but utilizes input and output belts which are enclosed in pressurized chambers which are maintained at a preselected partial vacuum. The enclosed nature of these chambers necessarily ~~[[limit]]~~ limits the number of parts that can be treated before the chambers have to be opened for loading a new batch to be processed. Additionally, the configuration of the input gate allows a very limited number of parts to be treated at once, and consequentially, the throughput of this system can be expected to be likewise limited. --

Please replace the paragraph beginning on page 6, line 6 with the following rewritten paragraph:

--It is ~~[[a]]~~ yet another object of the present invention to provide a DC bias to the electrodes in order to promote better penetration of plasma between parts. --

Please replace the paragraph beginning on page 9, line 13 with the following rewritten paragraph:

--A third preferred embodiment is a plasma treatment system for treating parts, which includes a reaction chamber, a device for supporting a number of parts in a multilevel array and a mechanism for generating a gas plasma and inducing a plasma reaction with the parts. The gas plasma mechanism ~~including~~ includes devices for applying Radio Frequency (RF) power and DC bias power to the gas plasma. This is

done by providing one or more electrodes through which RF is used to excite the gas to a plasma state, and the DC bias is also applied to one or more ~~electrodes~~ electrodes. This DC bias is used to direct the flow of the plasma, increase the ionic energy, and increase the ionization rate. By using vertically oriented electrodes, the plasma can be made to flow horizontally between the layers of a multilevel array that holds parts that are to be treated. The applied DC bias causes a more defined directionality of flow, which allows better penetration of the plasma to the multilevel array, and creates more uniformity of treatment. This improved penetration also allows closer spacing of parts and levels in a carrier, so that a carrier may have numerous levels configured into a "cassette" or "magazine". Use of ~~magazines~~ a magazine which ~~[[carry]]~~ carries a large number of parts ~~[[allow]]~~ allows increased throughput of parts, in either in-line, batch-processing or systems which use robotics. --

Please replace the paragraph beginning on page 12, line 15 with the following rewritten paragraph:

-- The preferred embodiment of the present invention is a plasma treatment system for increased throughput plasma treatment and cleaning of any of a variety of parts and components. The present invention can be used to increase efficiency and cut processing time in a number of different configurations, including in-line processing, batch processing, and processing which ~~[[use]]~~ uses robotics for material handling. The plasma treatment system of the preferred embodiment, although generally applicable to any substrate susceptible of plasma reaction, is directed toward use within the electronics industry, and more particularly toward assembly and packaging applications associated

therewith, and is set forth in Fig. 1, where it is designated therein by the general reference character 10. --

Please replace the paragraph beginning on page 15, line 26 with the following rewritten paragraph:

-- The versatility and capabilities of the push mechanism 20 (and the associated linear drive assembly 22) are of key importance to the advantages offered by the plasma treatment system 10 and the efficiency obtained thereby. As shown in the close-up view of Fig. 4, and in the end view of Fig. 5, the push mechanism 20 includes a vertically disposed drive attachment portion 58, a horizontally disposed, T-shaped arm member 60, which is joined to the top of the drive attachment portion 58 at the base of the "T", and first and second catch assemblies 62 and 64. The first and second catch assemblies (62 and 64) are located at each end of the cross portion of the "T" of the arm member 60 and include first and second catch actuators 66 and 68, respectively. The first and second catch actuators (66 and 68) act to lower and raise attached first and second catch fingers 70 and 72, which are horizontally disposed members having lengths that permit extension over the travel area of the PC board 28. The catch actuators (66 and 68) are commercially available pneumatic devices having air cylinders and spring returns. First and second catch blocks 74 and 76, present at the ends of the first and second catch fingers (70 and 72), respectively, and depending therefrom, permit abutable engagement of the PC board 28 when the catch fingers (70 or 72) are in a lowered position. A first and second catch sensor 75 and 77, which are of the infrared

variety, are also located at the ends of the first and second catch fingers (70 and 72), respectively, and provide for detection of the PC boards 28. It will be apparent that a variety of configurations for the dispositions and shapes of the components as comprise the push mechanism 20 may be employed to achieve the "catching" and "pushing" ability of the push mechanism 20 (the operation of which will be described in more detail later herein). For example, the catch actuators (66 and 68) might be relocated from the arm member 60 to the ends of the catch fingers (70 and 72), with the catch fingers (70 and 72) then attached directly to the arm member 60 and the catch blocks (74 and 76) attached directly to the catch actuators (66 and 68), such that only the catch blocks (74 and 76) are raised and lowered, among many other possible configurations. The push mechanism 20 might also take the form of a "pull[[[]]] mechanism" where parts are processed which accommodate this or are held in a holder adapted to permit such. Therefore, the description of the push mechanism 20 as applies to the invention 10 is not intended to be limited to just the particular arrangement as has been set forth. --

Please replace the paragraph beginning on page 19, line 6 with the following rewritten paragraph:

-- As is shown in Fig. 3b, after the last PC board 28 has been loaded, the first catch finger 70 is raised and the push mechanism 20 is moved by the linear drive assembly 22 to a location outside of the perimeter of the chamber base 16. At the same time, the conveyor position actuator 32 moves the conveyor 30 back out of the reaction chamber 14 area as well. The reaction chamber 14 is then lowered by the chamber lift

actuators 40 onto the chamber base 16, whereon the reaction chamber 14 is vacuum-tightly fittable, and the plasma process is initiated. Referring again to Fig. 2, there is shown a vacuum and plasma generating system 27 having a number of elements of generally conventional nature. A vacuum port 90, to which is connected a vacuum pump (not shown), provides that the reaction chamber 14 may be evacuated to a predetermined level, which is generally in the so-called "soft vacuum" region of 0.1-1.0 mm Hg. A gas distribution manifold 92 allows for the continuous introduction of process gas (e.g., oxygen and argon) within the reaction chamber 14. Flexible Teflon® tubing (not shown) provides that the gas manifold 92 may be raised in conjunction with the reaction chamber 14. A plasma is generated within the evacuated reaction chamber 14 with a radio frequency generator 94, there being provided for this purpose four radio frequency ~~feedthroughes~~ feedthroughs 96 which are located in the chamber base 16. An electrode 98 for the application of high voltage, to which the chamber guide rails 52 are clamped with guide rail clamps 100 (see FIG. 1) and conveniently supported thereby, provides that plasma reaction may then occur at the surface of the PC boards 28. It will be apparent to those with ordinary skill in the art that other electrical and radio frequency configurations for the chamber guide rails 52 might be employed. Thus, the chamber guide rails 52 might be radio frequency powered, or grounded, or electrically "floating" (isolated), or some combination of the foregoing. Additionally, a DC bias circuit can be included in the plasma treatment system to increase the directionality of plasma flow and the energy level of the ions and electrons in the plasma. The higher energy level also increases the ionization rate, thus increasing the number of ions and electrons. The

increased energy level and increased ionization rate both act to produce a higher etching rate and thus a shorter processing time. The increased bias also results in a more directional flow of ions onto the parts, resulting in a more anisotropic etching which is required when etching holes and vias. Anisotropic etching provides straight wall etching which decreases undercutting. This DC bias circuit is discussed in more detail below (see FIG. 12). --

Please replace the paragraph beginning on page 20, line 16 with the following rewritten paragraph:

-- To reiterate, since the plasma treatment system **10** incorporates a method of transfer that provides that no moving parts are located within the reaction chamber **14** during plasma treatment, no moving parts are degraded, and no contaminants (from machine oils or lubricants) are introduced onto the treated PC boards **28**. When the plasma treatment is completed, nitrogen is introduced into the reaction chamber **14** to bring the pressure of the reaction chamber **14** up to atmospheric level, and the reaction chamber **14** is again lifted up and out of the way via the chamber lift actuators **40**. Referring again to Figs. 1 and 2, and also to Fig. 3c, the output assembly **24** is comprised of components ~~essential~~ essentially identical to the conveyor input assembly **12**, but without a conveyor-belt type capability, and provides an analogously reverse function thereto. Thus, a position actuator **102** moves an output carrier **104**, which is mounted thereon, into close proximity to the unload end **56** of the chamber guide rails **52**. The second catch sensor **77** present on the push mechanism **20** locates the first

PC board 28, whereupon the second catch actuator 68 lowers the second catch finger and block (72 and 76) in order that the first PC board 28 may be pushed along the chamber guide rails 52 and unloaded onto an adjustable pair of output carrier guide rails 106. The output carrier 104 is then moved by the position actuator 102 (along an associated position actuator guide 108 as before ) away from the reaction chamber 14 so that transfer of the PC board 28 (by the push mechanism 20) to the next station may occur. The remaining PC board(s) 28' is moved onto the output carrier 104 by the push mechanism 20 in similar fashion. Prior to the re-lowering of the reaction chamber 14, and while the unloading of the treated PC boards 28 is occurring, untreated PC boards 28 are again loaded into the reaction chamber 14 for plasma treatment following the steps outlined above. In addition to the aforementioned advantages, the plasma treatment system 10 of the present invention provides that parts may be treated by plasma reaction without ever having to remove them from the assembly line, thereby reducing overall process time. --

Please replace the paragraph beginning on page 21, line 24 with the following rewritten paragraph:

-- Shown in the front view of Fig. 6 is an alternative embodiment of the present invention, in which there is provided a means by which an even greater number of PC boards or other parts may be subjected to simultaneous plasma treatment. The alternative embodiment employs components very similar to the aforementioned embodiment, but so modified as to achieve a multi-level loading of PC boards within the



reaction chamber and thereby making possible a multiplicatively increased throughput of PC boards or other parts. The alternative embodiment is designated as **410** in the drawings, and to the extent those elements of the alternative embodiment **410** are substantially identical (or closely correlate) to those previously appearing in the single-level embodiment **10**, they will be referred to by a reference number incorporating the original reference number prefaced with the digit "4". New elements which appear will be numbered in continuous fashion from previously numbered elements of the single-level embodiment **10**, beginning with the number "**110**". Referring now to both Fig. 6 and the top plan view of Fig. 7, a stationary conveyor **430** is essentially identical to the conveyor **30** of the single-level embodiment **10**, having a pair of adjustable conveyor guide rails **434** for receiving a PC board **28** from, e.g., a previous conveyor (not shown), but does not move upon a conveyor position actuator (**32**). An input carrier **110** does move along a first horizontal position actuator **432** in similar fashion to the previous conveyor and output carrier (**30** and **104**) and, in addition, is provided with a first vertical position actuator **112** and two pairs of adjustable upper and lower input guide rails **114** and **116** arrayed in bi-level fashion. The first vertical position actuator **112** acts to raise and lower the input carrier **110** such that when the input carrier **110** is in the lowered position the upper input guide rails **114** thereon are in co-planar and co-linear alignment with the conveyor guide rails **434**. Alternatively, when the input carrier **110** is in the raised position, the lower input guide rails **116** are made to be in alignment with the conveyor guide rails **434**. The vertical position actuator **112** is a commercially available pneumatic device, as before.--

Please replace the paragraph beginning on page 23, line 11 with the following rewritten paragraph:

As shown in FIG. 8, the multi-level embodiment 410 incorporates a linear drive assembly 422 as before, but a push mechanism 420 now includes first and second catch assemblies 462 and 464 having first and second catch actuators 466 and 468 which are attached not only to first and second lower catch fingers 470 and 472 (not shown) but to first and second upper catch fingers 124 and 126 (see FIG. 7) as well. The lengths of the catch fingers (470, 472, 124, and 126) are again such as to extend over the travel areas of the PC boards 28. In operation, and referring now to FIGS. 6 and 9a, and also to the end view of FIG. 10, a first catch sensor 475 present on the push mechanism 420 locates the PC board 28 as before. The first catch actuator 466 then lowers the first lower catch finger 470 such that a first catch block 474 may abut and push the PC board 28 when the linear drive assembly 422 is activated. The push mechanism 420 moves the PC board 28 onto the upper input guide rails 114 of the input carrier 110. The first vertical position actuator 112 then raises the input carrier 110 so that a second PC board 28' may be pushed onto the lower input guide rails 116. During the transfer, the upper catch fingers (124 and 126) are maintained in a raised state so that catch blocks 128 and 130 thereon do not [[to]] interfere with the first PC board 28 present on the upper guide rails 114. In addition, it will be noted that the two levels of the input carrier 110 are spaceably held apart by spacer members 132 which are located at one side of the input carrier 110 only, whereby the spacer members 132 do not interfere with the travel of the lower catch fingers (470 and 472) between the two levels. (The upper

and lower chamber guide rails (118 and 452) are similarly arranged.) --

Please replace the paragraph beginning on page 25, line 2 with the following rewritten paragraph:

-- The second level of the multi-level embodiment 410 doubles the number of parts that may be treated at one time. It is apparent, of course, that additional third and fourth levels, or more, could be added to further increase the throughput of parts. In addition, the different levels need not be ~~[[in]]~~ arranged in stacked alignment as shown, but rather might be staggered to achieve a close packing to the limit permitted by the need for a uniform plasma reaction. (A third position actuator that provides movement in a direction perpendicular to the horizontal position actuator 432 could be incorporated into the input and output carriers (110 and 122) in order to facilitate this. Similarly, the push mechanism 420 could incorporate additional actuators to provide for a retractable horizontal extension of the catch fingers (470 and 472) over more than one travel area. Such a system could be adapted for the single-level embodiment 10, as well.) --